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Kinematic assessment of distance and time parameters for children with cerebral palsy during the gait cycle

Kinematic assessment for cerebral palsy children during gait cycle

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Abstract

Aim: Cerebral palsy (CP) is a developmental disorder of motor, psychological and emotional functions. Its most typical symptom is a walking disorder. The aim of this study was to analyze children's walking abilities based on basic kinematic parameters, in addition, to identify and quantify distance and time parameters in hemiparesis cerebral palsy children by three-dimensional kinematic gait analysis. Material and Method: Kinematic motion analysis system during gait cycle was done in motion analysis lab in Delta University for Science & Technology which equipped with walkway and six infrared cameras operating at 60 HZ frequency. Gait analysis of (15) hemiparesis and (15) healthy children was quantified by the new anatomically based protocol of three dimensional kinematical gait analysis. Kinematic parameters in hemiparesis cerebral palsy and healthy children were identified and calculated. Results: The results of this study revealed that there was significant decrease in the speed of walking, stride length, step length and numbers of steps per unit of time (cadence) in the group of hemiparesis children during gait cycle compared to healthy children. Discussion: Current research proved that the patterns of walking of the paretic and non-paretic sides of hemiparesis CP children were different compared to healthy children.

Keywords

Cerebral Palsy; Walk, 3D Kinematics Analysis

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Introduction

Cerebral palsy (CP) describes a group of disorders of the development of movement and posture, causing activity limitation, that are attributed to non-progressive disturbances that occurred in the developing fetal or infant brain. The motor disorders of cerebral palsy are often accompanied by disturbances of sensation, cognition, communication, perception, and/or behavior, and/or by a seizure disorder [1-10].

Cerebral palsy (CP) is a relatively prevalent neurological disorder in children, occurring in (1.5 - 2.0 per 1000) live births. Impairment of upper limb movements, characterized by increased trajectory duration, reduced speed (peak and average), increased variability and less straight hand trajectories, is present in up to 80% of children with CP [9].

The damage in (CNS) central nervous system is caused by various etiological factors. The most typical symptoms of CP are the disorders of movement activities of various degrees and different locations [4].

These are most often contractures of limbs and trunk, mostly of spastic type, balance disorders and motor hyperactivity [7].

A special disorder is the restriction of walking efficiency or a child's inability to walk on its own. The lack of control is especially serious within the anklebone joint and foot [5].

The pathological mechanism of the foot movement is mostly visible in the stance phase of the gait cycle and it results from the foot structural deformation and/or contracture of muscles [6].

A child suffering from CP and experiencing the contractures of lower limb muscles often walks on its toes and distorts the foot in the inward direction [2,8].

In such cases, doctors can apply appropriate rehabilitation treatment or surgical operation consisting of TAL (Tendon-Achilles Lengthening). The operation does not always bring the expected results [3].

Human gait is a form of bipedal locomotion classify as continual state of imbalance caused by the integration between center of gravity (COG) and center of pressure COP. Every individual must constantly maintain postural stability while propelling himself forward to move in space [2].

From biomechanical point of view, the pattern of movement of human gait involves complex movement and requires coordination between sub phases of swing and stance phase during each gait cycle, which induce oscillations of (HAT) head, arms and trunk in both sagittal and coronal planes [1].

CP children have different levels of deficits in stability, which is a major component of the gait disorder [24].

Lack of scientific research in evaluation of the kinematic parameters of gait in children with hemiparetic cerebral palsy, so the purpose of this study is to evaluate and develop a suitable treatment plan of treatment for these cases.

Therefore, the aim of this study was to analyze children's walking abilities based on basic kinematic parameters in addition to identify and quantify distance and time parameters in hemiparesis cerebral palsy (CP) children by three dimensional kinematical gait analysis system which may help clinicians in making treatment decisions.

Material and Methods

An Ethics Committee of Delta University for Science and Technology approved the study. Written consent and Volunteer Information Sheet had authorized to Child's parents. All information about the aim of the study, its benefits and risks and their committee with regard to time and money have mentioned in these forms.

Subjects

The examinations of children with CP were carried out in the center for children with CP in the faculty of physical therapy at the Delta University for Science & Technology outpatient clinic and on the other hand, kinematic motion analysis during gait cycle was done in motion analysis laboratory at the Delta University for Science & Technology.

The study group consists of fifteen (15) hemiparesis CP children participated in our study with age range of (5-12) years, among them (10) were right hemiparesis and (5) left hemiparesis. The age, weight, and height of hemiparesis children were 7.6 ± 2.1 years, 26.3 ± 11.4 kg, and 124.2 ± 24.3 cm respectively.

Children with hemiparesis in the study group had no history of lower limbs surgery and absence of treatment by drugs or medication in the last year. Children with hemiparesis can walk without help or support; in addition, all patients were leg-dominant lower limb primarily involved with relative sparing of the upper limb [20].

The control group consists of fifteen (15) of healthy children; their age, weight, and height were 7.9 ± 6.1 years, 27.8 ± 16.1 kg, and 125.7 ± 11.7 respectively. The control group selection criteria included no history of cardiovascular or locomotors diseases. They had a normal degree of freedom in their joints motion, muscle power, and had no postural or balance defect.

The instrument used for gait analysis:

Gait analysis of (15) hemiparesis and (15) healthy children was quantified by the new anatomically based protocol of three-dimensional kinematical gait analysis system. Distance and time parameters in hemiparesis cerebral palsy and healthy children were identified and calculated.

Kinematic motion analysis system during gait cycle was done in motion analysis laboratory at the Delta University for Science & Technology which is equipped with a walkway and six infrared cameras operating at 60 HZ frequency. In addition, two Force plates embedded at the center of the walkway were used to determine the foot contact and foot-off events synchronized with the system made from motion analysis Company (Helen Hayes model).

Statistical analysis: The data, which collected from the control group and the study group, represent the statistical analysis by using the paired t test.

Sample size was almost small (N=15) because of the delimitation of study that the hemiparetic cerebral palsy children was not allowed and was not always feasible so the power analysis was low. And the confident interval was 95%.

Results

There was no significant difference between the study group (hemiparesis children) and control group (healthy children) in regards to height, weight, and age.

A p -value < 0.05, compared between paretic and non-paretic sides of hemiparesis CP children.

Our study proved that the pattern of walking of the paretic and non-paretic sides of hemiparesis CP children were different compared to healthy children.

On the paretic side of hemiparesis, CP children there was observed short duration of stance phase percent (weight bearing or supporting phase) in comparison with a non-paretic side of

Table 1. The mean (standard deviation) of distance and time parameters for children with CP during the gait cycle versus normal healthy children.

Distance and time parameters of Gait	Non paretic side CP	Paretic side CP	Healthy children
Stance (%gait cycle)	62.24 (4.15)	57.72(2.82)	60.29 (2.20)
Swing (%gait cycle)	37.76 (4.15)	42.28(2.82)	39.71 (2.20)
Double limb stance time (DLS)	11.58 (3.88)	10.45 (4.54)	10.70 (1.82)
Step length	39.44 (11.02)	41.83 (12.11)	47.13 (9.21)
Stride length	81.59 (21.37)	80.01 (21.71)	92.45 (17.32)
Width of BOS	16.27 (5.79)	15.24 (4.68)	12.87 (3.00)
Velocity (cm/s)	84.23 (24.20)	82.88 (24.90)	94.13 (21.28)
Cadence	113.95 (17.18)	112.18 (16.06)	122.39 (18.53)

hemiparesis CP children and healthy children ($P<0.05$).
The results of this study revealed that there was a significant decrease in the speed or velocity of walking, stride length, step length and numbers of steps per unit of time (cadence) in the group of hemiparesis CP children during gait cycle compared to healthy children ($P< 0.05$).
The width of BOS markedly increased in hemiparesis CP children compared to healthy children. On the other hand, there was no significant difference in the double support time (DLS) in both study and control groups.

Discussion

The result of this study revealed that there were a significant decrease in walking speed, stride length and Cadence in hemiparetic cerebral palsy group compared to healthy children group.
On the paretic side of hemiparesis CP children was observed short duration of stance phase percent (weight bearing or supporting phase) in comparison with non-paretic side of hemiparesis CP children and healthy children ($P < 0.05$).
About 33% of CP children have hemiplegia with weakness and spasticity predominantly affecting one side of the body and the deficit concerns the motor ability of the body's side opposite to the site of cerebral lesion [16, 17& 18].
Our study was almost agreed with the study examined the Muscles that commonly spastic in children with CP including (iliopsoases ,hamstrings ,quadriceps, gastrocnemius, soleus, and calf muscles); in addition to the ankle muscles like tibialis anterior. Spasticity of these muscles adversely affects the energy efficiency required for functional balance, and hence affects the normal gait cycle [15].
Some studies examined the distance and time parameters for children with cerebral palsy during gait cycle, one of these studies done to compare between the right and left hemiplegic pattern of walking using three-dimensional kinematical gait analysis to analyze the difference in pattern of walking. The results of this study proved that right hemiplegic gait walked with higher speed than left hemiplegic gait [21].
Another study done to assess the distance and time parameters for children with cerebral palsy during gait cycle and reported that, hemiparetic children walked more slowly with shorter step length, longer swing time than normal children and decreased cadence [23] .
Another research done to analyze the gait strategy of uninvolved limb in children with spastic hemiplegia and reported that uninvolved limbs had significant longer stance phase, knee joint more flexed, hip joint presented high flexion at the beginning of gait cycle and ankle kinematics presented values closed to normal . The results of this study support previous observations which showed that analysis of walking movement pattern of hemiparetic CP children presents unique motor strategy different from healthy subjects [22].
Current study proved that, the pattern of walking of the paretic and non-paretic sides of hemiparesis CP children were different compared to healthy children.
The results of this study revealed that, there was significantly decrease in the speed or velocity of walking, stride length, step length and numbers of steps per unit of time (cadence) in the group of hemiparesis CP children during gait cycle compared to healthy children ($P< 0.05$).
Width of BOS increased considerably in hemiparesis CP children compared to healthy children. On the other hand, there was no significant difference in the double support time (DLS) in both study and control groups.
Walking velocity is the product of step length and cadence, hence reduction in either one parameter may account for gait slowing and it might be considered a strategy in order to obtain a better stability and equilibrium during walking.
The shorter duration of stance phase (weight bearing or supporting phase) on the paretic side compared to non-paretic CP and healthy children is related to the deficient ability to load and transfer weight through their affected leg. It has been proposed that improving weight transfer through the affected leg during progressive training with the feet of the patients placed in a variety of diagonal position may improve gait symmetry in hemiplegic [19].
Finally from clinical point of view, the identification of the kinematic parameters either distance or time variables in hemiparetic CP children can be helpful in the diagnosis and allow physiotherapists to suggest what exercise program should be develop in order to improve the pattern of walking.

Scientific Responsibility Statement
The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement
All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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Conflict of interest
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